**Homework 4**

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ISyE 6420

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# Question 4.1

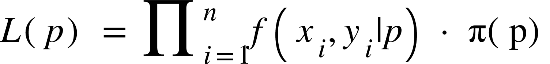
## 4.1.a)

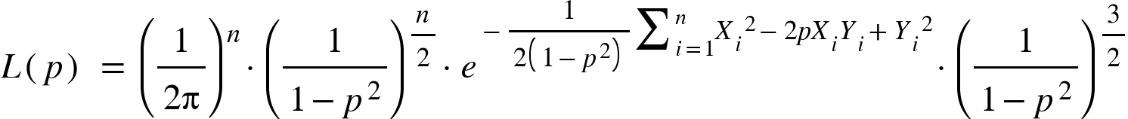
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## 4.1.b)

The general formula for a Metropolis algorithm involves finding an expression for alpha, which is based on the proposed posterior and the distribution of a particular parameter.

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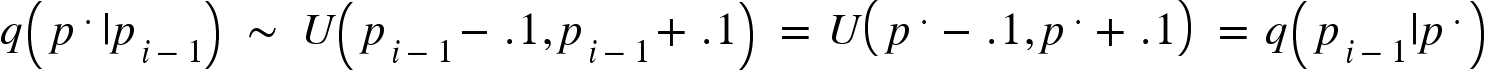
From the information in part b, we know the following:

Our variable, p\*, is distributed around U(pi-1-0.1, pi-1+0.1). Each time we run the code, we calculate a new p\* variable based on the current p value.

Note that q(p\*|pi-1) follows a uniform distribution U(pi-1-0.1, pi-1+0.1), where the probability density function (pdf) is 1/(pi-1+0.1 - (pi-1-0.1)) = 1/0.2 = 5.

Similarly, q(p|p\*) has a similar distribution, where the pdf is 1/(p\*+0.1 - (p\*-0.1)) = 1/0.2 = 5.

Note this makes sense given the symmetric nature of uniform distributions.



So, it stands that since the q functions are equal, they cancel out, and our new formula is:

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Let’s apply the given assumptions from part b and plug them into our alpha function.

Highlighted below are the key pieces of code which correspond to the above findings.

Here’s the appropriate code:

function metropolis\_algorithm()

% Number of samples including burn-in

total\_samples = 51000;

% Initialize rho value and storage

current\_rho = 0;

rho\_samples = zeros(total\_samples, 1);

% Observed data summaries

sample\_size = 100;

sum\_of\_x\_squares = 115.9707;

sum\_of\_y\_squares = 105.9196;

sum\_of\_xy = 84.5247;

for i = 2:total\_samples

% Propose a new rho using a symmetric random walk proposal

proposed\_rho = current\_rho - 0.1 + rand() \* 0.2;

proposed\_rho = min(max(proposed\_rho, -1), 1); % Ensure it's between -1 and 1

% Compute Metropolis-Hastings acceptance probability

current\_posterior = compute\_unnormalized\_posterior(current\_rho, sample\_size, sum\_of\_x\_squares, sum\_of\_y\_squares, sum\_of\_xy);

proposed\_posterior = compute\_unnormalized\_posterior(proposed\_rho, sample\_size, sum\_of\_x\_squares, sum\_of\_y\_squares, sum\_of\_xy);

acceptance\_probability = min(1, proposed\_posterior / current\_posterior);

% Accept or reject the proposed rho

if rand() < acceptance\_probability

current\_rho = proposed\_rho;

end

% Store the current rho sample

rho\_samples(i) = current\_rho;

end

end

% Compute unnormalized posterior density for a given rho value

function post = compute\_unnormalized\_posterior(rho, n, sum\_x2, sum\_y2, sum\_xy)

% Non-informative prior for rho

prior = 1 / (1 - rho^2)^(3/2);

if rho <= -1 || rho >= 1

prior = 0;

end

% Gaussian likelihood based on observed data

likelihood = (1/(2\*pi\*sqrt(1 - rho^2)))^n \* exp(-1/(2\*(1-rho^2))\*(sum\_x2 - 2\*rho\*sum\_xy + sum\_y2));

% Return the unnormalized posterior

post = prior \* likelihood;

end

## 4.1.c)

I ran the function 10 times, and while all of my answers were slightly different, they appeared to be distributed around 0.737 with little variance.

Bayes estimator of rho: 0.73714

Acceptance rate: 0.5177

Histogram:

![A diagram of a distribution of a number of objects

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confidence](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RD0RXhpZgAATU0AKgAAAAgABAE7AAIAAAAOAAAISodpAAQAAAABAAAIWJydAAEAAAAcAAAQ0OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAE1hZ2dpZSBGcmFzZXIAAAWQAwACAAAAFAAAEKaQBAACAAAAFAAAELqSkQACAAAAAzY2AACSkgACAAAAAzY2AADqHAAHAAAIDAAACJoAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Last 1000 simulations.

![A graph showing a number of blue lines

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RD0RXhpZgAATU0AKgAAAAgABAE7AAIAAAAOAAAISodpAAQAAAABAAAIWJydAAEAAAAcAAAQ0OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAE1hZ2dpZSBGcmFzZXIAAAWQAwACAAAAFAAAEKaQBAACAAAAFAAAELqSkQACAAAAAzY4AACSkgACAAAAAzY4AADqHAAHAAAIDAAACJoAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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/68pv/AEA18/0UAf/Z)

## 4.1.d)

When we alter the uniform distribution to U(-1,1), we observe intriguing phenomena. Upon re-executing the code, the outcomes presented noteworthy patterns.

Bayes estimator of rho: 0.73884

Acceptance rate: 0.056236

![A screenshot of a computer

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RD0RXhpZgAATU0AKgAAAAgABAE7AAIAAAAOAAAISodpAAQAAAABAAAIWJydAAEAAAAcAAAQ0OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAE1hZ2dpZSBGcmFzZXIAAAWQAwACAAAAFAAAEKaQBAACAAAAFAAAELqSkQACAAAAAzgzAACSkgACAAAAAzgzAADqHAAHAAAIDAAACJoAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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unXk13NfXV/dSxpCZroplUXJCgIqjqxJOMknk8DGpRQAUUUUAZHiDw8niGG1jlv7u0W2mE6i3EZDsOm5ZEYEA8gY64PUCoZPDLymCZ9c1L7dAska3oEAkMb4yhAi2EZVSPlyCOvWt2igDnJfBNgbcW9pdXllA1mllPHBIv+kQrnAcspOfmYblIb5jz0x0KIscapGoVVACgdAKdRQAUjKHQqwyGGCKWigDm18EWMkQh1G8vdRgjtZLSCK6dSIY3GGwVUMW2gDcxJwOuSSXt4Ptp45zfahfXdzKsKpdytGJIfKbfGU2oFBDfNkg5PXI4roaKAM/StIj0v7S/2ie6uLqXzZ7icruchQoGFAAAAAAAH5kmtCiigArN1jw/pmu20sWpWUEzSRNEJmiVpIwQR8pIODzke9aVFAHPXPgywlQx2txc2EMtqtncRWhRFniUnAbKnB+Zxldp+Y89MPm8I2ct5JItzdQ2s00VxNYxlBDLJGFCk/LuH3EyAwB2jI653qKACiiuZ0/xzp17/Y8cwFtPqzTCKN5F+Xy2K89D8xGBgc0Ab19Zx6jp89nOXEc8ZjYxuVYAjGQRyD71iv4OtrkTSahqF9eXciRJHdymMSQeW+9Cm1AoO8BiSDnvkcVrQavptzfy2NtqFrNdw/6y3jmVpE+qg5FR/wBv6OYZ5Rq1j5duqtM/2lNsQYZUsc8AjpnrQBQ/4RK3I80396b/AO1faxf5j80Ps8vGNmzbs+Xbtxg5681paVpcOkWItoZJJSXeWSWYgvK7MWZmwAMknsAB0AAqhf8AjDRLG1sbn+0LaeC+uVtopop0ZMnqS2cYHf6irI12zgsprrVbi00+GO4kgEkt0m07WIGWzgE4zt6joaANOiqU+s6Za2qXN1qNpDBInmJLJOqqy8fMCTgj5hz7j1qzb3EN3bpPazRzQyDckkbBlYeoI4NAGLd+ErS8vLiRru7jtruZJ7qyRk8qd024JypYZ2LkKwB289TlYfCdpDfJL9puntYriS6isXKeTHLJu3MPl3Hl3IBYgFjxwMbtFAGJpPha20m5t5VvLu5SzgNvZxTspW2jJGQuFBPCqMsScDryc7dFFABVbUrFNT0q7sJpJI47qB4WeIgOoZSpKkg4PPHFWaKAMy/0O3vbayjjlmtJLBw9tNBt3REKUx8wIIKsQQQevrg1SXwhbwpbtZ6hfWt5D5269jaMyy+awaTfuQqcsAeFGMDGBxXQUUAVtOsINL023sbNSsFvGI0BOTgDuT1PvVmiigArn4vB9pHcRbru7ls4Ll7qKwkKGFJGJOfu7yAWYgFiBnpwMdBRQBzcPgjT1tvst1c3d5apaPZQQTuu23hfAKqVUEnCqAzEkBRg9c6Gl6GunXk13NfXV/dSxpCZroplUXJCgIqjqxJOMknk8DGpRQAUUUUAUtT006ikPl3t1ZSwSeYktsyg5wQQQwKsCCeCD2IwQDWYPCFtElu1lf31pdwiYNeRtGZZfNYNJv3IVOWAPAGMDGBxXQUUAc5L4JsDbi3tLq8soGs0sp44JF/0iFc4DllJz8zDcpDfMeemOhRFjjVI1CqoAUDoBTqKACqWsaXDrejXemXTSJDdRGJ2jIDAH0yCM/hV2igDE1Xwxb6rdTz/AGy7tPtVuLa7S2ZQLiMEkK2VJH3mGVIOGPPTCal4VtdRmldLu7sluLZbS5jtWRVniUnCnKkjAZhlSDhjz0xuUUAYM3hGzlvJJFubqG1mmiuJrGMoIZZIwoUn5dw+4mQGAO0ZHXO9RRQAUUUUAFZviT/kVdW/68pv/QDWlWb4k/5FXVv+vKb/ANANAGlRXM/8LE8Lf9BT/wAl5f8A4mj/AIWJ4W/6Cn/kvL/8TQB01Fcz/wALE8Lf9BT/AMl5f/iaP+FieFv+gp/5Ly//ABNAHTUVzP8AwsTwt/0FP/JeX/4mj/hYnhb/AKCn/kvL/wDE0AdNRXM/8LE8Lf8AQU/8l5f/AImj/hYnhb/oKf8AkvL/APE0AdNRXM/8LE8Lf9BT/wAl5f8A4mj/AIWJ4W/6Cn/kvL/8TQB01Fcz/wALE8Lf9BT/AMl5f/iaP+FieFv+gp/5Ly//ABNAHTUVzP8AwsTwt/0FP/JeX/4mj/hYnhb/AKCn/kvL/wDE0AdNRXM/8LE8Lf8AQU/8l5f/AImj/hYnhb/oKf8AkvL/APE0AdNRXM/8LE8Lf9BT/wAl5f8A4mj/AIWJ4W/6Cn/kvL/8TQB01Fcz/wALE8Lf9BT/AMl5f/iaP+FieFv+gp/5Ly//ABNAHTUVzP8AwsTwt/0FP/JeX/4mj/hYnhb/AKCn/kvL/wDE0AdNRXM/8LE8Lf8AQU/8l5f/AImj/hYnhb/oKf8AkvL/APE0AdNRXM/8LE8Lf9BT/wAl5f8A4mj/AIWJ4W/6Cn/kvL/8TQB01Fcz/wALE8Lf9BT/AMl5f/iaP+FieFv+gp/5Ly//ABNAHTUVzP8AwsTwt/0FP/JeX/4mj/hYnhb/AKCn/kvL/wDE0AdNRXM/8LE8Lf8AQU/8l5f/AImj/hYnhb/oKf8AkvL/APE0AdNXmOmaZe2tp4SebT7qOSNr6Fn+yuxgeRj5bOACVXPO48Drmuo/4WJ4W/6Cn/kvL/8AE0f8LE8Lf9BT/wAl5f8A4mgDkPDOk3Sf8I1Y3K6ql5psoeaM6YsUcDBGEhNwVAdWyfusS24E98TWWmz6R8O/CcSaN5MqtG15M2nPcSWjCNzvMK/MzbjtyQdu4nFdT/wsTwt/0FP/ACXl/wDiaQfEbwqSQNU+6cH/AEeX/wCJoA4yGwu45Lq9utO1G4gXxFbXZZ9NKvJF5Cq0giRc43DkAZ/vc5q9plnPpXiRNU1jTLyWwW81VU2WjzNC8l0GSXy1UttZAQGAPX0NdN/wsTwt/wBBT/yXl/8AiaP+FieFv+gp/wCS8v8A8TQBzeg6DM/inSbm60mSKw83VLi3imgwLZJHh2BlxhC2HIU4PJ966fwTZy2GkX1vLbvbIuq3phjZCgEZncqVH90g5GOMGmf8LE8Lf9BT/wAl5f8A4mj/AIWJ4W/6Cn/kvL/8TQB01Fcz/wALE8Lf9BT/AMl5f/iaP+FieFv+gp/5Ly//ABNAHTUVzP8AwsTwt/0FP/JeX/4mj/hYnhb/AKCn/kvL/wDE0AdNRXM/8LE8Lf8AQU/8l5f/AImj/hYnhb/oKf8AkvL/APE0AdNRXM/8LE8Lf9BT/wAl5f8A4mj/AIWJ4W/6Cn/kvL/8TQB01Fcz/wALE8Lf9BT/AMl5f/iaP+FieFv+gp/5Ly//ABNAHTUVzP8AwsTwt/0FP/JeX/4mkX4jeFWGRqmeSP8Aj3l/+JoA6eiuZ/4WJ4W/6Cn/AJLy/wDxNH/CxPC3/QU/8l5f/iaAOmormf8AhYnhb/oKf+S8v/xNH/CxPC3/AEFP/JeX/wCJoA6aiuZ/4WJ4W/6Cn/kvL/8AE0f8LE8Lf9BT/wAl5f8A4mgDpqK5n/hYnhb/AKCn/kvL/wDE0f8ACxPC3/QU/wDJeX/4mgDpqK5n/hYnhb/oKf8AkvL/APE0f8LE8Lf9BT/yXl/+JoA6aiuZ/wCFieFv+gp/5Ly//E0f8LE8Lf8AQU/8l5f/AImgDpqK5n/hYnhb/oKf+S8v/wATSf8ACxvCu4r/AGpyBkj7PL/8T7UAdPRXM/8ACxPC3/QU/wDJeX/4mj/hYnhb/oKf+S8v/wATQB01ZniYkeE9XKjJFjNgZxn92azP+FieFv8AoKf+S8v/AMTVDXfHnhy88O6jbWupbp5rWWONTBIMsUIA5X1NAH//2Q==)

Utilizing the independent proposal distribution *U*(−1,1), we suggested new values for *ρ* without referencing the current state of the chain. This methodology resulted in a significant decline in the acceptance rate due to the broader range of values and the inherent randomness in selecting subsequent variables. This led to heightened autocorrelation within the chain. This approach allows for a thorough exploration of the parameter space but often requires a larger sample size for accurate target distribution approximation. In MCMC, it's typically wiser to choose proposal distributions informed by the target distribution or the chain's current state.

# Question 4.2.

## 4.2.a)

A black background with a black square

Description automatically generated with medium confidence

## 4.2.b)

% Given parameters

totalSamples = 21000; % Total number of samples

observedEvents = 20; % Number of observed events

totalTime = 522; % Total observed time

c\_param = 3; % Parameter c for gamma distribution

d\_param = 1; % Parameter d for gamma distribution

alpha\_param = 100; % Parameter alpha for gamma distribution

beta\_param = 5; % Parameter beta for gamma distribution

initialMu = 0.1; % Initial value for mu

% Run the Gibbs Sampler to obtain lambda and mu samples

[lambdaSamples, muSamples] = gibbsSampler(totalSamples, observedEvents, totalTime, c\_param, d\_param, alpha\_param, beta\_param, initialMu);

% Discarding the initial samples for burn-in

burnInPeriod = 1000;

lambdaSamples = lambdaSamples(burnInPeriod+1:end);

muSamples = muSamples(burnInPeriod+1:end);

% Gibbs Sampler Function

function [lambdaSamples, muSamples] = gibbsSampler(totalSamples, observedEvents, totalTime, c, d, alpha, beta, mu\_initial)

% Initialize the samples arrays

lambdaSamples = zeros(1, totalSamples);

muSamples = zeros(1, totalSamples);

muSamples(1) = mu\_initial; % Set the initial mu sample

% Perform the Gibbs Sampling iterations

for i = 2:totalSamples

% Sample lambda based on the latest mu value

lambdaSamples(i) = gamrnd(observedEvents + c, 1 / (muSamples(i-1) \* totalTime + alpha));

% Sample mu based on the latest lambda value

muSamples(i) = gamrnd(observedEvents + d, 1 / (lambdaSamples(i) \* totalTime + beta));

end

end

Highlighted are the key functions to run the Gibbs Sampler.

## 4.2.c)

>> Gibbs\_Sampler\_2b

Posterior mean for lambda: 0.053973

Posterior variance for lambda: 0.00036864

Posterior mean for mu: 0.69248

Posterior variance for mu: 0.067785

95% credible interval for lambda: [0.024667, 0.099322]

95% credible interval for mu: [0.31394, 1.3141]

Histograms and Scatterplots.

![A screenshot of a computer

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RD0RXhpZgAATU0AKgAAAAgABAE7AAIAAAAOAAAISodpAAQAAAABAAAIWJydAAEAAAAcAAAQ0OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAE1hZ2dpZSBGcmFzZXIAAAWQAwACAAAAFAAAEKaQBAACAAAAFAAAELqSkQACAAAAAzAyAACSkgACAAAAAzAyAADqHAAHAAAIDAAACJoAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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## 4.2.d)

Bayesian estimate for lambda \* mu: 0.033652

**Matlab Code**

4.1.c:

function sample\_posterior\_rho()

% Number of samples including burn-in

total\_samples = 51000;

% Initialize rho value and storage

current\_rho = 0;

rho\_samples = zeros(total\_samples, 1);

% Observed data summaries

sample\_size = 100;

sum\_of\_x\_squares = 115.9707;

sum\_of\_y\_squares = 105.9196;

sum\_of\_xy = 84.5247;

% Counter for accepted Metropolis-Hastings proposals

accepted\_count = 0;

for i = 2:total\_samples

% Propose a new rho using a symmetric random walk proposal

proposed\_rho = current\_rho - 0.1 + rand() \* 0.2;

% Clip proposed rho to ensure it's between -1 and 1

proposed\_rho = min(max(proposed\_rho, -1), 1);

% Compute Metropolis-Hastings acceptance probability

current\_posterior = compute\_unnormalized\_posterior(current\_rho, sample\_size, sum\_of\_x\_squares, sum\_of\_y\_squares, sum\_of\_xy);

proposed\_posterior = compute\_unnormalized\_posterior(proposed\_rho, sample\_size, sum\_of\_x\_squares, sum\_of\_y\_squares, sum\_of\_xy);

acceptance\_probability = min(1, proposed\_posterior / current\_posterior);

% Decide whether to accept the proposal

if rand() < acceptance\_probability

current\_rho = proposed\_rho;

accepted\_count = accepted\_count + 1;

end

% Store the current sample

rho\_samples(i) = current\_rho;

end

% Report acceptance rate

acceptance\_rate = accepted\_count / (total\_samples - 1);

% Discard burn-in samples

burn\_in = 1000;

rho\_samples = rho\_samples(burn\_in+1:end);

% Plot posterior histogram

figure;

histogram(rho\_samples, 50, 'Normalization', 'pdf');

xlabel('\rho');

ylabel('Density');

title('Posterior distribution of \rho');

% Plot trace of last 1000 realizations

figure;

plot(rho\_samples(end-999:end));

xlabel('Iteration');

ylabel('\rho');

title('Last 1000 realizations of the chain');

% Report posterior mean as the Bayes estimator for rho

bayes\_estimator\_rho = mean(rho\_samples);

disp(['Bayes estimator of rho: ', num2str(bayes\_estimator\_rho)]);

disp(['Acceptance rate: ', num2str(acceptance\_rate)]);

end

% Compute unnormalized posterior density for a given rho value

function post = compute\_unnormalized\_posterior(rho, n, sum\_x2, sum\_y2, sum\_xy)

% Non-informative prior for rho

prior = 1 / (1 - rho^2)^(3/2);

if rho <= -1 || rho >= 1

prior = 0;

end

% Gaussian likelihood based on observed data

likelihood = (1/(2\*pi\*sqrt(1 - rho^2)))^n \* exp(-1/(2\*(1-rho^2))\*(sum\_x2 - 2\*rho\*sum\_xy + sum\_y2));

% Combine prior and likelihood to compute unnormalized posterior

post = prior \* likelihood;

end

4.1d:

function sample\_posterior\_rho()

% Number of samples including burn-in

total\_samples = 51000;

% Initialize rho value and storage

current\_rho = 0;

rho\_samples = zeros(total\_samples, 1);

% Observed data summaries

sample\_size = 100;

sum\_of\_x\_squares = 115.9707;

sum\_of\_y\_squares = 105.9196;

sum\_of\_xy = 84.5247;

% Counter for accepted Metropolis-Hastings proposals

accepted\_count = 0;

for i = 2:total\_samples

% Propose a new rho using a symmetric random walk proposal

proposed\_rho = -1 + 2\*rand();

% Clip proposed rho to ensure it's between -1 and 1

proposed\_rho = min(max(proposed\_rho, -1), 1);

% Compute Metropolis-Hastings acceptance probability

current\_posterior = compute\_unnormalized\_posterior(current\_rho, sample\_size, sum\_of\_x\_squares, sum\_of\_y\_squares, sum\_of\_xy);

proposed\_posterior = compute\_unnormalized\_posterior(proposed\_rho, sample\_size, sum\_of\_x\_squares, sum\_of\_y\_squares, sum\_of\_xy);

acceptance\_probability = min(1, proposed\_posterior / current\_posterior);

% Decide whether to accept the proposal

if rand() < acceptance\_probability

current\_rho = proposed\_rho;

accepted\_count = accepted\_count + 1;

end

% Store the current sample

rho\_samples(i) = current\_rho;

end

% Report acceptance rate

acceptance\_rate = accepted\_count / (total\_samples - 1);

% Discard burn-in samples

burn\_in = 1000;

rho\_samples = rho\_samples(burn\_in+1:end);

% Plot posterior histogram

figure;

histogram(rho\_samples, 50, 'Normalization', 'pdf');

xlabel('\rho');

ylabel('Density');

title('Posterior distribution of \rho');

% Plot trace of last 1000 realizations

figure;

plot(rho\_samples(end-999:end));

xlabel('Iteration');

ylabel('\rho');

title('Last 1000 realizations of the chain');

% Report posterior mean as the Bayes estimator for rho

bayes\_estimator\_rho = mean(rho\_samples);

disp(['Bayes estimator of rho: ', num2str(bayes\_estimator\_rho)]);

disp(['Acceptance rate: ', num2str(acceptance\_rate)]);

end

% Compute unnormalized posterior density for a given rho value

function post = compute\_unnormalized\_posterior(rho, n, sum\_x2, sum\_y2, sum\_xy)

% Non-informative prior for rho

prior = 1 / (1 - rho^2)^(3/2);

if rho <= -1 || rho >= 1

prior = 0;

end

% Gaussian likelihood based on observed data

likelihood = (1/(2\*pi\*sqrt(1 - rho^2)))^n \* exp(-1/(2\*(1-rho^2))\*(sum\_x2 - 2\*rho\*sum\_xy + sum\_y2));

% Combine prior and likelihood to compute unnormalized posterior

post = prior \* likelihood;

end

4.2.c

% Given parameters

totalSamples = 21000; % Total number of samples

observedEvents = 20; % Number of observed events

totalTime = 522; % Total observed time

c\_param = 3; % Parameter c for gamma distribution

d\_param = 1; % Parameter d for gamma distribution

alpha\_param = 100; % Parameter alpha for gamma distribution

beta\_param = 5; % Parameter beta for gamma distribution

initialMu = 0.1; % Initial value for mu

% Run the Gibbs Sampler to obtain lambda and mu samples

[lambdaSamples, muSamples] = gibbsSampler(totalSamples, observedEvents, totalTime, c\_param, d\_param, alpha\_param, beta\_param, initialMu);

% Discarding the initial samples for burn-in

burnInPeriod = 1000;

lambdaSamples = lambdaSamples(burnInPeriod+1:end);

muSamples = muSamples(burnInPeriod+1:end);

% Calculate the posterior means and variances for lambda and mu

posteriorMeanLambda = mean(lambdaSamples);

posteriorVarianceLambda = var(lambdaSamples);

posteriorMeanMu = mean(muSamples);

posteriorVarianceMu = var(muSamples);

disp(['Posterior mean for lambda: ', num2str(posteriorMeanLambda)]);

disp(['Posterior variance for lambda: ', num2str(posteriorVarianceLambda)]);

disp(['Posterior mean for mu: ', num2str(posteriorMeanMu)]);

disp(['Posterior variance for mu: ', num2str(posteriorVarianceMu)]);

% Compute the 95% equitailed credible intervals for lambda and mu

credibleIntervalLambda = [quantile(lambdaSamples, 0.025), quantile(lambdaSamples, 0.975)];

credibleIntervalMu = [quantile(muSamples, 0.025), quantile(muSamples, 0.975)];

disp(['95% credible interval for lambda: [', num2str(credibleIntervalLambda(1)), ', ', num2str(credibleIntervalLambda(2)), ']']);

disp(['95% credible interval for mu: [', num2str(credibleIntervalMu(1)), ', ', num2str(credibleIntervalMu(2)), ']']);

% Plot histograms for lambda and mu samples

figure;

subplot(2,1,1);

histogram(lambdaSamples, 50, 'Normalization', 'pdf');

title('\lambda samples');

subplot(2,1,2);

histogram(muSamples, 50, 'Normalization', 'pdf');

title('\mu samples');

% Scatter plot of lambda vs mu samples

figure;

scatter(lambdaSamples, muSamples, 5);

xlabel('\lambda');

ylabel('\mu');

title('Scatter plot of \lambda and \mu samples');

% Gibbs Sampler Function

function [lambdaSamples, muSamples] = gibbsSampler(totalSamples, observedEvents, totalTime, c, d, alpha, beta, mu\_initial)

% Initialize the samples arrays

lambdaSamples = zeros(1, totalSamples);

muSamples = zeros(1, totalSamples);

muSamples(1) = mu\_initial; % Set the initial mu sample

% Perform the Gibbs Sampling iterations

for i = 2:totalSamples

% Sample lambda based on the latest mu value

lambdaSamples(i) = gamrnd(observedEvents + c, 1 / (muSamples(i-1) \* totalTime + alpha));

% Sample mu based on the latest lambda value

muSamples(i) = gamrnd(observedEvents + d, 1 / (lambdaSamples(i) \* totalTime + beta));

end

end

4.2.d:

% Given parameters

totalSamples = 21000; % Total number of samples

observedEvents = 20; % Number of observed events

totalTime = 522; % Total observed time

c\_param = 3; % Parameter c for gamma distribution

d\_param = 1; % Parameter d for gamma distribution

alpha\_param = 100; % Parameter alpha for gamma distribution

beta\_param = 5; % Parameter beta for gamma distribution

initialMu = 0.1; % Initial value for mu

% Run Gibbs Sampler to get lambda, mu samples and their products

[lambda\_samples, mu\_samples, products] = gibbs\_sampler(totalSamples, observedEvents, totalTime, c\_param, d\_param, alpha\_param, beta\_param, initialMu);

% Discarding the initial samples (burn-in)

burnInPeriod = 1000;

lambda\_samples = lambda\_samples(burnInPeriod+1:end);

mu\_samples = mu\_samples(burnInPeriod+1:end);

products = products(burnInPeriod+1:end);

% Calculate Bayesian estimate for the product lambda \* mu

bayesianEstimate = mean(products);

disp(['Bayesian estimate for lambda \* mu: ', num2str(bayesianEstimate)]);

% Gibbs Sampler Function

function [lambda\_samples, mu\_samples, products] = gibbs\_sampler(totalSamples, observedEvents, totalTime, c, d, alpha, beta, mu\_initial)

% Initialization

lambda\_samples = zeros(1, totalSamples);

mu\_samples = zeros(1, totalSamples);

products = zeros(1, totalSamples);

mu\_samples(1) = mu\_initial;

products(1) = 0; % Initialized with just the mu\_initial

% Start Gibbs Sampling iterations

for i = 2:totalSamples

% Sample lambda using latest mu value

lambda\_samples(i) = gamrnd(observedEvents + c, 1 / (mu\_samples(i-1) \* totalTime + alpha));

% Sample mu using latest lambda value

mu\_samples(i) = gamrnd(observedEvents + d, 1 / (lambda\_samples(i) \* totalTime + beta));

% Compute and save the product of the current lambda and mu

products(i) = lambda\_samples(i) \* mu\_samples(i);

end

end